

The Role of Enzymes in Food Flavors^{a, b}

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THE SCIENCE OF FOOD PROCESSING is today much concerned with problems of flavor. These problems relate to objectives which fall roughly into three groups, depending upon the type of food and the aims of the food processor: (a) to present to the consumer food that is instantly recognizable as fresh, (b) to prepare food so that it has the flavor of freshly prepared fresh food, and (c) to prepare food which conforms to the consumer's notions of desirable flavor.

The purpose of this paper is to summarize the important aspects of flavor development in foods and to outline a method of flavor restoration in processed foods.

The flavor concept in nature. Characteristic flavors (odor and taste) of fruits, vegetables, other fresh foods, and fresh biological materials are due to chemical compounds produced by the organisms as a result of its normal metabolic processes. Presumably such flavors have been formed from other chemical substances, which can be called flavor precursors. The flavor precursors have themselves been formed from their precursors, making it possible to picture the formation of a series of chemical substances in a chain of reactions which might begin with carbon dioxide, sunlight, water, and minerals.

These chemical changes are brought about by the catalytic effect of enzymes, the naturally occurring proteinaceous materials found in the organism. Enzymes are often highly specific for bringing about the chemical changes in each step of the complicated process whereby the flavor precursor is built up and then converted into the flavor itself. These enzymes are heat sensitive and lose their ability to catalyze chemical reactions on being heated. They can also be inactivated by other means, such as irradiation or "poisoning" by certain chemical compounds.

Flavor as a processing problem. Processing food is basically a stabilizing process. Stabilizing is achieved by substantially destroying or inactivating all the enzymes. This is most commonly done by a heat process, blanching, in which the food is subjected to wet heat consisting usually of hot water or steam. The blanched food is then subjected to further processing (such as freezing, canning, dehydration) to prevent or retard chemical changes and growth of bacteria on storage.

Result of the process is that the food no longer contains active enzymes. Depending upon the methods of processing, there will be other changes from the fresh food, some additive, some subtractive in nature. As far as flavor is concerned, the effect is deleterious because many of the flavor components are volatile or heat labile. Thus, in the study of food products it is important to determine what part the flavors of the fresh food (that is, the enzymatically produced flavors) play in the desirable flavors of the food or food products as presented to the consumer. The flavor of processed foods may be compounded of the fresh flavor which has persisted through processing, flavors which come from conversion of the fresh flavors originally present, and flavors which arise during processing.

Utilization of "latent" flavor sources. Non-volatile, relatively heat stable compounds present in the food will survive processing, and among these will be the flavor precursors. It follows, then, that the flavor precursors which survive processing represent a source of latent or potential flavor. If this potential can be converted to flavor, a valuable improvement in the processed food will have been made. We have found that these sources of flavor in processed foods can be converted into actual flavor by the addition of the proper enzymes, the isolation and characterization of which have been tasks of considerable complexity. It is not possible within the limits of the present article to trace the course of this work.

Illustrated graphically in Figures 1 and 2 is the abstract model of flavor development and restoration.

Flavorese. The enzyme(s) necessary for conversion of the flavor precursor(s) to the flavor(s), we have called "flavorese" enzymes.^c These flavorese enzymes can be obtained from the fresh biological material before processing, or from a biologically related source, by one of the usual processes for the preparation of enzymes.

It is not necessary to obtain an absolutely pure sample of flavorese enzyme, since a relatively crude enzyme preparation will be effective if it contains a high enough concentration of the desired enzyme. If, however, it contains some unwanted enzymes (not concerned with the formation of fresh flavor), then it would be desirable to add the crude enzyme just prior to the preparation of the food for consumption. The specificity of the flavorese enzymes is indicated by the fact that none of the readily available industrial enzymes gave the same effects as the flavorese enzymes.

^a This work was carried out under contract with the Quartermaster Research and Development Command, Natick, Massachusetts. It is part of a continuing study of the flavors and off-flavors of fruits and vegetables. The first part of this research was reported at the 129th American Chemical Society meeting in Dallas, April, 1956.

^b Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 13, 1956.

^c The suffix, *ese*, indicates that the enzyme(s) are concerned with the formation of flavors. The more commonly used suffix, *ase*, refers to the nature of the substrate upon which the enzyme acts.

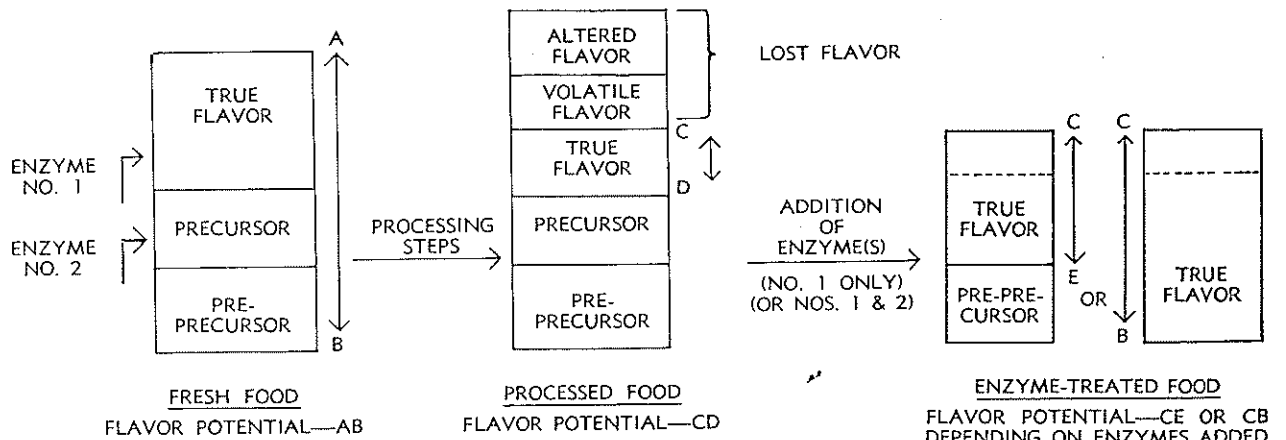


Figure 1. Flow diagram of natural flavor development, loss in processing, and restoration by enzyme additive.

EXPERIMENTAL RESULTS

Fresh watercress was blanched in steam and dehydrated in an oven at about 60° C. for 3 hours. The dehydrated material was quite flavorless and had none of the characteristic taste and smell of watercress. When water was added to this material, no change was observed. The reconstituted watercress smelled and tasted like hay.

However, when a tasteless, odorless, enzyme preparation from white mustard seeds (white mustard and watercress both belong to the *Brassica* family) was added to the dehydrated watercress in water, the typical odor and taste of watercress was regained within a few minutes. Enzyme preparations from black mustard seed and cabbage seed were also effective.

Using the same enzymes, a similar effect was obtained with dehydrated cabbage. Other materials, such as celery, leek, spinach, pineapples, onions, tomatoes, oranges, bananas, parsley, strawberries, milk, and carrots, have been shown to be capable of similar improvement by the use of the appropriate enzymes.

Since the presence of the precursor is required in the processed food for the effect of enzyme addition to be

observed, it is clear that for maximum effect the conditions of processing must be such that the precursor is preserved throughout processing to the greatest possible extent. Thus it may be more desirable to plan the processing treatment with the intent of securing the maximum precursor survival than to plan for the maximum flavor survival.

This is illustrated by the case of watercress. The enzyme in watercress responsible for converting the precursor to the flavor is very heat labile and the conditions of dehydration (60° C.) are sufficient to inactivate it. Thus, when watercress is dehydrated without previous blanching, the product is flavorless, and rehydration brings back no flavor. When dehydrated unblanched watercress is compared with dehydrated steam-blanch watercress and with dehydrated boiling water-blanch watercress, all are found to be bland and flavorless. However, when the white mustard enzyme preparation is added to the water of rehydration, a marked difference appears. The unblanched quickly regains its strong taste and smell. The steam-blanch has, by comparison, a moderately strong regain, and the boiling water-blanch has only a weak regain of characteristic flavor. Moreover, the water

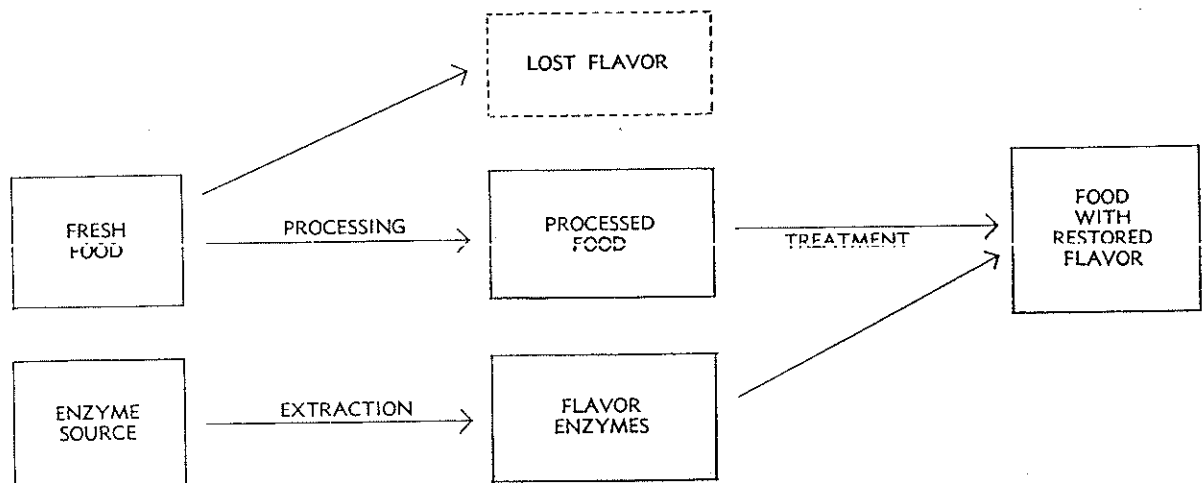


Figure 2. Restoration of natural flavor to processed foods by enzyme treatment.

used for the hot water blanch is quite flavorless, but on treatment with the enzyme soon develops a strong watercress flavor. This proves that hot water-blanching has leached out the precursor and reduced the potential flavor of the processed watercress. It also shows that steam blanching is to be preferred in this case although even this leads to slight losses.

CONCLUSION

An understanding of these principles can be of great advantage in designing conditions for the commercial processing of foods. Severe flavor losses may be tolerated in order to preserve the precursors; the latent flavor from the precursor more than compensates for the flavor loss.